Report 989

4807/6

LYCOMING

DIVISION - THE AVIATION CORPORATION

WILLIAMSPORT, PENNA.

INITIAL OPERATION OF A SINGLE REED VALVE COMBUSTION CHAMBER

LYCOMING
DIVISION--THE AVIATION CORPORATION

REPORT NO. 989

Date of Test:

January 28, 1946 to February 9, 1946

Date of Report:

March 7, 1946

INITIAL OPERATION OF A SINGLE REED VALVE COMBUSTION CHAMBER

Reported by:

S. P. Mitchell
S. P. Mitchell

Approved by:

B. J. Ryder
B. J. Ryder
Chief Experimental Engineer

A. T. Briggs
A. T. Briggs
Project Engineer

C. H. Wiegman
C. H. Wiegman
Chief Engineer

Distribution:

Mr. C. H. Wiegman
Mr. A. T. Briggs
Engineering Records
Experimental File
Aeropulse Laboratory
Navy Dept. Bureau of Aeronautics (5)

LYCOMING
DIVISION--THE AVIATION CORPORATION

REPORT NO. 989

INITIAL OPERATION OF A SINGLE REED VALVE COMBUSTION CHAMBER

Index

LYCOMING
DIVISION--THE AVIATION CORPORATION

REPORT NO. 989

INITIAL OPERATION OF A SINGLE REED VALVE COMBUSTION CHAMBER

OBJECT:

1. The object of this report is to present the data and observations obtained during the initial operation of a single reed valve on a model combustion chamber for the period thru February 9, 1946.

SUMMARY:

2. In order to obtain air flow data on the reed valve proposed for the second combustion chamber to be built under Item III of Contract NOa(s)-4718, a single Reed valve was constructed and flow tested. See Reports No. 928 and 936.

3. Subsequently this reed valve assembly was welded into a piece of pipe provided with spark plugs and a fuel injection nozzle to form a crude combustion chamber.

4. The data given herein cover the results of the preliminary runs with this crude model. Three reed valves were tested under various operating conditions, the maximum time of operation on any one reed was 9 hours and 29.5 minutes. The preliminary results of the tests of this model with the single reed valve were very encouraging and such to indicate that it would be a very useful tool in the development program of a combustion chamber of this type.

CONCLUSIONS:

5. It is concluded that:

a) A combustion chamber employing a fixed size open nozzle exhaust, an automatic inlet valve and constant spark ignition can be made to fire in cyclic order by injecting fuel at regular intervals.

b) The reed valve shows promise as an automatic inlet valve for intermittently firing combustion chambers.

acs

c) The single reed valve unit is a very useful tool to expedite the development program of a combustion chamber using this type of valve.

d) The scavenging of the combustion chamber depends upon the location of the exhaust opening as well as the size.

RECOMMENDATIONS:

6. It is recommended that:

a) A more durable small combustion chamber with water cooling and a better nozzle entrance be constructed for use in endurance testing of single reed valve assemblies.

b) A single reed valve combustion chamber should be used for the investigation of temperature drift in dynamic pick-ups.

DESCRIPTION:

7. The single reed valve combustion chamber model was assembled as shown on drawing No. 70614 or as illustrated on page 10 of this report. The valve assembly consisted of the valve seat plate on the inlet side, the valve cover or stop plate on the exit side and the valve reed, Lycoming No. 70723 between the two plates.

8. Photo No. E-4038 on page 19 shows the reed on the seat with the cover plate at the side.

9. Photo No. E-4039 on page 20 shows the reed between the seat plate and cover plate.

10. In photo No. E-4042 on page 21 the reed valve assembly is shown attached to the combustion chamber.

11. The single reed valve unit was mounted on a test bench and connected to an air supply tank and to a Bosch fuel injection pump as shown on photo No. E-4041 on page 22.

12. The fuel pump, drive unit, mount and all equipment other than the single reed valve chamber assembly are equipment designed and assembled for other tests and are consequently larger units than would have been required for only the single valve test.

13. The fuel pump is made of two units, Bosch numbers EJN7648-62 Serial EG4035-17 and EJN7648-7 Serial EG4035-16.

14. The injector nozzle is a Bendix part number 135026 Lycoming serial No. 21.

15. The Bosch fuel pump with the surge tank is shown with the drive and electric tachometer in photograph No. E-4040 on page 23.

16. The original .281 jet hole is shown in the plate on photo No. E-4041 on page 22.

17. Photo No. E-4042 on page 21 shows the fuel injector surrounded by a coil to spray cooling water against the injector end of the chamber. The line for cooling the main chamber is shown above the unit.

18. A General Electric Company Catalog 5102 neon light transformer serial 2004784 supplied a continuous arc through two spark plugs with .050 gap.

METHOD OF TEST:

19. The initial test was conducted on January 28, 1946 with a reed of Brown & Sharpe gage stock as received to find conditions under which the unit would operate. The fuel used during all tests was 73 octane aviation gasoline.

20. The first reed was replaced by a reed of the same material heat treated to Rockwell C 40-45 and testing continued on January 29, 1946.

21. A surge tank was installed in a line connecting the inlet chambers of the Bosch pumps to minimize the fuel surge.

22. Thermocouples were located as shown on page 10.

23. An electric tachometer was connected to the fuel pump drive to determine the I.P.M. (fuel injections per minute).

24. The fuel system was connected through a 14 to 220 lb./hr. rotameter and through the Pittsburgh type displacement meter.

25. The air tank was connected to pressure gages to record the ram air pressure.

26. On February 7, a uniflow ball check valve was installed between the combustion chamber and a 0 - 600 PSI indicating gage to record peak cylinder pressures.

27. With the preliminary instrumentation installed, the plan was to operate in one-half hour intervals starting at 300 IPM and continue with increased IPM until difficulty was encountered.

28. In attempts to increase the limiting number of injections per minute, tests were conducted with dual and single ignition, with water spray on the fuel injector end and on the cylinder, and with different nozzle opening combinations.

29. Short interval operation was also attempted with auto-ignition.

RECORD OF TESTS:

30. In the summary of test variables shown on page 9, the runs are identified by date and time. The reed valves are identified by number. The letter "R" given after the nozzle diameter signifies a smooth approach.

31. The recorded data are given on page 12 through page 18.

32. The first test on January 28, 1946 showed that the unit would operate at around 200 cycles per minute but that the life of the soft valve was of the order of five minutes before mal-firing occurred due to distortion of the valve.

33. One hour of operation on January 29, 1946 with the hardened valve indicated continued investigation with preliminary instrumentation was desirable.

34. With the hardened valve (#2) the unit would operate at 300 IPM (injections per minute) but mal-firing occurred after short operation at 400 IPM. It was noted that the injector plate temperatures started increasing rapidly with mal-firing occurring within 8 minutes when the IPM was increased from 300 to 400.

LYCOMING
DIVISION--THE AVIATION CORPORATION

REPORT NO. 989

35. The second attempt to operate at 400 IPM confirmed the above.

36. Number 2 valve was examined and found to be in good condition.

37. The valve was installed with the convex side toward the inlet or valve seat side.

38. When the top injector end spark plug wire was removed so the unit was operating on the single ignition spark from the jet end plug, the exhaust flame shortened. By increasing the fuel flow the length of the flame was increased and made equivalent to the dual ignition flame. Stabilized operation was possible up to 350 IPM. With this single plug location flash readings indicated that 500 IPM was the maximum value for short interval cyclic operation.

39. The top injector end plug wire was reconnected and the jet end plug disconnected. The temperatures of the chamber were higher at 300 IPM than were observed for the 350 IPM operation with the other plug. However, flash operation indicated that smooth cyclic operation with the injector end plug alone was possible up to 800 IPM.

40. A water spray was added to cool the fuel injector nozzle end of the chamber, extending stabilized operation on dual ignition from 300 to 600 IPM.

41. The maximum cyclic frequency with stabilized operation as in the preceding paragraph was further increased to 1000 IPM by machining a smooth approach in the .281 diameter nozzle.

42. A series of flash readings were taken to determine the maximum chamber peak pressures at the various IPM with the optimum throttle setting and with the ram air pressure limited by the output of the 6409 Ingersoll Rand compressor. The results are plotted on Curve No. 6619 on page 11.

43. Number 2 reed was damaged in attempting to increase the bow or tension in the reed and number 3 reed was installed.

44. The jet flange gasket blew out as tests were to be started with a .315 dia. nozzle. The flame first shortened and then increased to the longest flame encountered during the period covered by this report as the fuel supply was increased. Peak combustion pressures were correspondingly increased.

45. When normal operation was resumed with the .315 diameter nozzle, the maximum frequency was extended from 1000 to 1200 IPM.

46. At 600 IPM the peak combustion pressures were considerably above values recorded for stabilized operation at the same cyclic frequency with other jet openings. After 17 minutes of operation at 600 IPM the cyclic speed was increased to 805 IPM. During this interval, the peak combustion pressure was 200-210 psi with ram air pressures of 50-55 psi. After 4.5 minutes of operation at 805 IPM, the valve failed. The net nozzle area was then increased by drilling three equally spaced .187 inch diameter holes in the nozzle plate close to the outer diameter of the chamber.

47. Photo No. E-4036 on page 24 shows the valve reed in place as seen when the ram air approach was removed.

48. Photo No. E-4037 on page 25 shows the exit side of the reed and valve seat plate.

49. Photos No. E-4034 and 4035 on pages 26 and 27 show the valve reed as removed from the housing.

DISCUSSION:

50. From the first test with the soft reed valve it was apparent that the reed valve had possibilities but that a soft valve was not satisfactory.

51. A heat treated valve was operated for one hour. The condition of the valve was found to be quite satisfactory with no indications of deterioration.

52. After preliminary instrumentation was installed the valve was tried with the convex side and the concave side toward the seat. Although conclusive tests were not conducted it is believed that the convex side should be toward the inlet

or valve seat. The best initial bow or tension was not determined.

53. The preliminary work with the spark plug locations clearly indicates that the position of the spark relative to the chamber or fuel spray is important. Further work on spark plug locations was deferred for later consideration due to the major differences in the combustion chambers of the single reed valve and the full scale multi reed single cylinder design.

54. From the general performance of the unit, it was believed that the major factor which limited the IPM and caused mal-firing during the first few tests was the temperature of the fuel injector nozzle and the gasoline. It was interesting to note that in some cases mal-firing could be overcome by increasing the fuel flow to extremely rich values and then returning to a normal operating fuel flow. Probably the injector was fuel cooled from this procedure. This was not a permanent fix as temperatures would again increase to the point where mal-firing was present. The high fuel temperature of the fuel injector probably caused vapor locks and nozzle dribbling at irregular intervals resulting in mal-firing of the engine. The limiting temperature of the injector end of the cylinder seemed to be of the order of 850°. This value probably would change with the rate of fuel flow. The fuel temperature limitation was apparently overcome by the use of the water spray on the fuel injector nozzle end of the chamber.

55. The water line was added to spray water on the top of the chamber to avoid difficulty with portions of the equipment not of primary interest during the tests.

56. After the high temperatures around the fuel injector nozzle were reduced by water cooling further increases in the cyclic operating frequency were made by enlarging the effective size of the exhaust jet. The experience with a blown exhaust jet flange gasket and the four hole combination exhaust jet demonstrated that increased performance was dependent upon the location of the exhaust opening as well as the size. With the relatively large ratio between the

cross sectional area of the combustion chamber and the single nozzle area there were apparently large volumes of unscavenged gas.

57. A cylindrical combustion chamber of similar volume but of smaller diameter and with a gradual reduction in cross sectional area to the jet area should improve the scavenging with a single nozzle.

58. The failure of the valve occurred at a point where the seat had been erroded by a leak between the reed and the seat. As the leak between the reed and seat increased, the localized heating of the valve probably caused the failure of the reed. This condition can be improved by a change in the design or material of the seat.

TEST _____ FORM 707 AF

LYCOMING
Division - The Aviation Corporation

ENGINE LOG

Date _____ Test No. _____ 27 PAGES. PAGE 1 REPORT NO. 363

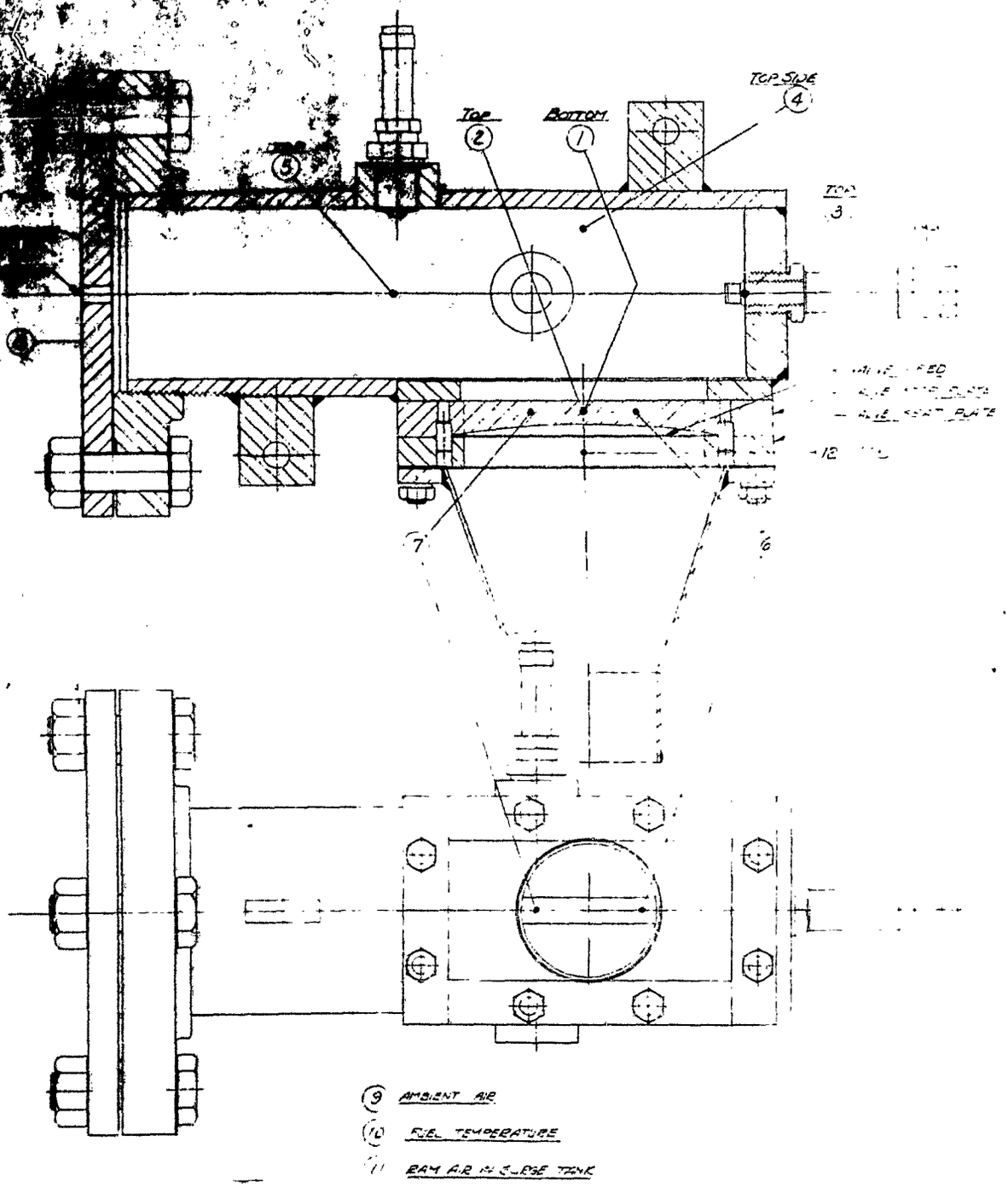
Engine Type _____ No. _____ Sheet No. _____

Compression Ratio _____

	RUN NUMBER																						
1	DATE	1-28-46	1-29-46	2-2-46				2-4-46								2-5-46							
2	TIME - STARTING		2:24	10:30	11:00	12:06	12:31	10:20	10:40	12:52	1:12	1:23	1:50	2:12	2:21	9:58	10:13	10:32	10:47	11:08	11:22	11:39	2:55	3:26
3	REED	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	SPARK PLUG TOP INJ. END	ON	ON	ON	ON	ON	ON	ON	ON	ON				ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
5	BOTTOM INJ. END																							
6	SIDE JET END	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON				ON	ON	ON	ON	ON	ON	ON	ON
7	JET - MAIN SIZE	.281	.281	.281	.281	.281	.281	.281	.281	.281	.281	.281	.281	.281	.281	.281	.281	.281	.281	.281	.281	.281	281R	281R
8	AUX # 2																							
9	AUX # 3																							
10	AUX # 4																							
11	WATER SPRAY - INJ END															ON	ON	ON	ON	ON	ON	ON	ON	ON
12	TOP CYL.																						ON	ON
13	I. P. M.		200	300	400	303	400	300	350	300	300	350	500	300	600	300	350	400	450	500	550	600	700	800
14	REED BOW TO SEAT	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	OFF	ON	ON	ON
15	TIME - STABILIZED			10:45		12:26		10:30			1:16	1:30				10:10	10:23	10:45	10:52	11:11	11:30	12:00	3:11	3:41
16	NOTE				A		A		A				B	A	B					C				
17																								
18																								
19																								
20																								
21																								
22																								
23																								
24																								
25																								
26	DATE	2-5-46	2-7-46											2-8-46			2-9-46							
27	TIME - STARTING	3:58	1:59	2:15	2:51	3:26	3:27	3:28	3:30	3:32	3:33	3:35	3:37	3:10	3:41	3:55	10:03	10:12						
28	VALVE	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3						
29	SPARK PLUG TOP INJ. END	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON						
30	BOTTOM INJ. END																							
31	SIDE JET END	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON						
32	JET - MAIN SIZE	281R	281R	281R	281R	281R	281R	281R	281R	281R	281R	281R	281R	315R	315R	316R	315R	315R						
33	AUX # 2																.187	.187						
34	AUX # 3																.187	.187						
35	AUX # 4																.187	.187						
36	WATER SPRAY - INJ END	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON						
37	TOP CYL.	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON						
38	I.P.M.	550	805	912	1000	875	800	700	600	500	400	300	250	1000	1100	1200	600	805						
39	REED BOW TO SEAT	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON											
40	TIME - STABILIZED	4:11	2:10	2:20	3:05																			
41	NOTE					C	C	C	C	C	C	C	C											
42																								
43																								
44																								
45	NOTE A - "A" DENOTES RUNS WHERE TEMPERATURES COULD NOT BE STABILIZED BEFORE MAL FIRING OCCURRED.																							
46	NOTE B - "B" DENOTES FLASH READINGS WHERE NO ATTEMPT WAS MADE TO STABILIZE.																							
47	NOTE C - "C" DENOTES RUNS MADE TO RECORD PEAK CYLINDER PRESSURES.																							
48																								

Recorded by _____

THERMOCOUPLE LOCATIONS

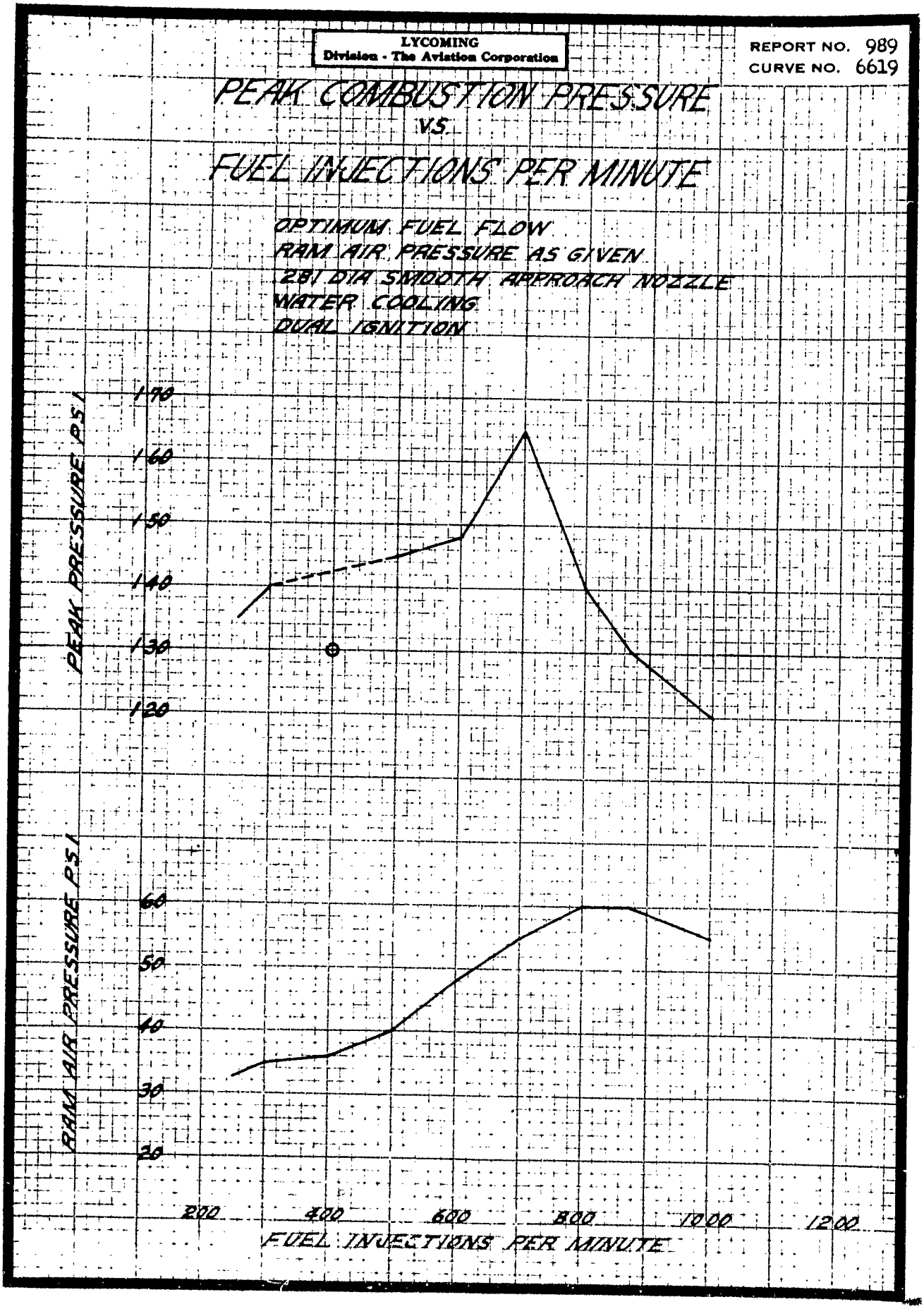


LYCOMING
Division - The Aviation Corporation

REPORT NO. 989
CURVE NO. 6619

PEAK COMBUSTION PRESSURE V.S. FUEL INJECTIONS PER MINUTE

OPTIMUM FUEL FLOW
RAM AIR PRESSURE AS GIVEN
.281 DIA SMOOTH APPROACH NOZZLE
WATER COOLING
DUAL IGNITION



TEST _____ FORM 707 AF LYCOMING Division - The Aviation Corporation Date _____ Test No. 27 Pages, Page 12 Report No. 989

Engine Type _____ No. _____ Sheet No. 1

Compression Ratio _____

ENGINE LOG

CONFIDENTIAL

FUEL - 73 OCTANE AVIATION GASOLINE

	RUN NUMBER																							
1	DATE		1-28-46		1-29-46			2-2-46											2-4-46					
2	TIME				2:34	3:34		10:30	10:45	11:00	11:08		12:06	12:26	12:31	12:34	12:38		10:20	10:30	10:40	10:44.5	10:45	10:49
3	R.P.M. x 4							1200	1200	1600	1600		1210	1210	1600	1210	1210		1200	1200	1200	1400	1400	
4	I.P.M.		200		200			300	300	400	400		303	303	400	303	303		300	300	300	350	350	
5	RAM AIR PRESS.	P.S.I.	32					34.4	30.5	30.6	31.4		31.7	35	36	34	34		31	30.3	31.2	33	33	
6	COMB. CH'B'R. TEMP.	°F																		900	870	1200	1220	
7	ROTOMETER	LB./HR.																						
8	FUEL QUAN.	GAL.																						
9	FUEL TIME	MIN. SEC.																						
10	GAS TEMP.	°F																						
11	PEAK COMB. PRESS.	P.S.I.																						
12																								
13	CYLINDER TEMP. INJ. END	°F							640	620				620						640	630			
14	VALVE STOP INJ. END	°F							590	540				540						560	580			
15	VALVE STOP JET END	°F							610	630				615						570	590			
16																								
17	TIME INTERVAL	MIN:MIN.	:05			1:					:38						:32						:29	
18	TOTAL TIME	MIN:MIN.				1:05					1:43						2:15						2:44	
19																								
20	NOTE NUMBER		1	2			3	4			5						6	7-9					10	11
21																								
22																								
23																								
24																								
25																								
26																								
27																								
28																								
29																								
30																								
31																								
32																								
33																								
34																								
35																								
36																								
37																								
38																								
39																								
40																								
41																								
42																								
43																								
44																								
45																								
46																								
47																								
48																								
49																								
50																								

Note 1 - The Reed Valve as described in Report No. 928 was installed in the test unit and operated for approximately five min. The up-stream air pressure was set for 32 PSI gage. The injection pump was timed for approximately 200 injections per minute. The ignition was continuous from the neon light transformer using two spark plugs - .050" gap - one on each high tension lead. The upstream air pressure was taken from the 80 gal. receiver of the 10 hp 2 stage compressor and regulated by a quick acting gate valve. A 30 gal. boiler, connected to the Reed Valve Adapter with a 2-1/4" I.D. Hose, is used as a surge arrestor in the air system.

Note 2 - A heat treated valve was installed.

Note 3 - A surge tank was incorporated in the fuel system. A tachometer and thermocouple were incorporated in the set-up.

Note 4 - During this period of operation, the valve bow was such that the convex side of the valve was toward the combustion chamber.

Note 5 - The flame shortened. The cylinder started to glow from the jet plate flange to the rear of the valve plate. The 31.4 ram air pressure dropped to 28.2 after the fuel was shut off.

Note 6 - Mal-firing was accompanied by intermittent black smoke.

Note 7 - The valve was found to be in good condition. No distortion was apparent although the valve had been contacting the stop plate.

Note 8 - The thermocouple was installed thru the injector and of the combustion chamber near the side opposite the valve.

Note 9 - The valve was installed with the convex side toward the seat.

Note 10- Mal-firing again occurred. Increasing the fuel flow for a short time would reenstate firing.

Note 11- The valve was found to be in good condition.

Recorded by _____

TEST _____ FORM 707 AF LYCOMING Division - The Aviation Corporation Date _____ Test No. Report No. 989

Engine Type _____ No. _____ Sheet No. 2

Compression Ratio _____

ENGINE LOG

CONFIDENTIAL

FUEL - 73 OCTANE AVIATION GASOLINE

	RUN NUMBER																								
1	DATE		2-4-46																						
2	TIME		12:52	1:00	1:10	1:12	1:15	1:17	1:22	1:23	1:30	1:32	1:33	1:38	1:40	1:44	1:47	1:50	1:52.5		2:10	2:12	2:18	2:21	2:39
3	R.P.M. X 4		1200	1200	1200	1200	1200	1200	1200	1400	1400	1400	1400	1400	1400	1400	1400	2000	2000		1200	1200	1200		
4	I.P.M.		300	300	300	300	300	300	300	350	350	350	350	350	350	350	350	500	500		300	300	300	800	
5	RAM AIR PRESS.	P.S.I.	30.	31.	31.2	31.2	31.5	31.5	31.4	34	34.5	34.5	44	30.5	30.	30.5	30.5	32.5	32.5			345	31.2		
6	COMB. CH'BR. TEMP.	°F		890	870	740	510	760	730	880	895	900	740	840	1000	1040	1040	1430	1435			1080	1050		
7	ROTOMETER	LB./HR.																							
8	FUEL QUAN.	GAL.																							
9	FUEL TIME	MIN. SEC.																							
10	GAS TEMP.	°F																							
11	PEAK COMB. PRESS.	P.S.I.																							
12																									
13	CYLINDER TEMP. INJ. END	°F					550		600		600			550		640	680						700		
14	VALVE STOP INJ. END	°F					480		400		540			490		590	655						610		
15	VALVE STAP JET END	°F					650		670		690			650		750	800						665		
16																									
17	TIME INTERVAL	HR: MIN.																							
18	TOTAL TIME	HR: MIN.	2:44																1:026						:39
19																			3:445						4:136
20	NOTE NUMBER					12							13		14				15		16			17	18
21																									
22																									
23																									
24																									
25			Note 12 - Removing the ignition wire from the injector end spark plug caused the flame to shorten. Operation was with jet end plug only. The flame was returned to previous appearance by increasing the fuel flow.																						
26																									
27																									
28			Note 13 - The air was increased with no change in the fuel setting.																						
29																									
30			Note 14 - The air was decreased with no change in the fuel setting.																						
31																									
32			Note 15 - The maximum flash IPM was about 500.																						
33																									
34			Note 16 - Operation was with injector end plug only.																						
35																									
36			Note 17 - The maximum flash operation was 800 IPM.																						
37																									
38			Note 18 - The temperature at the fuel nozzle was thought to be responsible for the mal-firing.																						
39																									
40																									
41																									
42																									
43																									
44																									
45																									
46																									
47																									
48																									
49																									
50																									

Recorded by _____

TEST _____ Form 707 AF LYCOMING Date _____ Test No. _____

Division - The Aviation Corporation

Engine Type _____ No. _____ Sheet No. 3

FUEL,- 73 OCTANE AVIATION GASOLINE

ENGINE LOG

Compression Ratio _____ CONFIDENTIAL

	RUN NUMBER																							
1	DATE		2-5-46																					
2	TIME		9:58	10:05	10:10	10:13	10:23	10:30	10:32	10:40	10:41	10:45	10:46	10:47	10:52	10:57	11:07	11:08	11:11	11:21	11:22	11:30	11:31	11:39	11:45
3	R.P.M. X 4		1200	1200	1200	1400	1400	1400	1600	1600	1600	1600	1600	1800	1800	1800	1800	2000	2000	2000	2200	2200	2200	2400	2400
4	I.A.M.		300	300	300	350	350	350	400	400	400	400	400	450	450	450	450	500	500	500	550	550	550	600	600
5	RAM AIR PRESS.	P.S.I.	30	30.5	30.8	32.6	33.8	34.2	33.5	34.2	34	38	38	38.5	39.5	40	39.5	40	41	41.5	43	45	44	45	44.5
6	COMB. CH'B'R. TEMP.	°F	—	480	535	760	840	930	1140	1220	1150	1200	—	1330	1400	1320	1340	1490	1500	1500	1460	1600	1590	1580	1600
7	ROTOMETER	LB./HR.																							
8	FUEL QUAN.	GAL.																							
9	FUEL TIME	MIN:SEC.																							
10	GAS TEMP.	°F																							
11	PEAK COMB. PRESS.	P.S.I.																							
12																									
13	CYLINDER TEMP. INJ. END	°F			70			150				160			130				120			80			
14	VALVE STEM INJ. END	°F			180			330				450			630				720			930			
15	VALVE STEM JET END	°F			300			550				680			840				910			960			
16																									
17	TIME INTERVAL	HR:MIN.																							
18	TOTAL TIME	HR:MIN.	4:13.5																						
19																									
20	NOTE NUMBER		19										20												
21																									
22																									
23																									
24																									
25																									
26																									
27																									
28																									
29																									
30																									
31																									
32																									
33																									
34																									
35																									
36																									
37																									
38																									
39																									
40																									
41																									
42																									
43																									
44																									
45																									
46																									
47																									

Note 19 - A water spray was added to cool the injector end.

Note 20 - Unit was firing on auto ignition for five minutes.

TEST _____ FORM 707 AF LYCOMING Division - The Aviation Corporation

Date _____ Test No. _____ 27 Pages, Page 15 Report No. 909

Engine Type _____ No. _____ Sheet No. 4

Compression Ratio _____ CONFIDENTIAL

FUEL - 73 OCTANE AVIATION GASOLINE

ENGINE LOG

	RUN NUMBER																							
1	DATE		2-5-46	CONT.																				
2	TIME		11:50	11:52	11:55	12:00	12:04	2:55	3:02	3:06	3:11	3:21	3:26	3:28	3:34	3:41	3:47	3:56	3:56.5	3:58	4:06	4:11	4:16	4:20
3	R.P.M. X 4		2400	2400	2400	2400			2800	2800	2800	2800	2800	3200	3200	3200	3200	3200	3200	3400	3400	3400	3400	
4	I.P.M.		600	600	600	600			700	700	700	700	700	800	800	800	800	800	800	850	850	850	850	
5	RAM AIR PRESS.	P.S.I.	42.5	44.8	45.	44.3			51.4	50	51.6	52	53	60	60.5	59.5	60	59.5	59.7	65	65.5	64.8	61	
6	COMB. CH'B'R. TEMP.	°F	1400	1350	1260	1340			1590	1560	1650	1620	1620	1630	1740	1730	1760	1780	1790	1730	1630	1640	1740	
7	ROTOMETER	LB./HR.													15	14.3	14.6	14.7	14	15.2	16.2	15.8	16.6	
8	FUEL QUAN.	GAL.																			.6			
9	FUEL TIME	MIN. SEC.																			14:00.5			
10	GAS TEMP.	°F																			64.5			
11	PEAK COMB. PRESS.	P.S.I.																						
12																								
13	CYLINDER TEMP. INJ. END	°F				100					330					140						150		
14	VALVE STEM INJ. END	°F				550					620					910						990		
15	VALVE STEM JET END	°F				870					1180					1275						1290		
16																								
17	TIME INTERVAL	HR:MIN.					2:06																1:25	
18	TOTAL TIME	HR:MIN.					6:19.5																7:44.5	
19																								
20	NOTE NUMBER							21-24																
21																								
22																								
23																								
24																								
25																								
26																								
27																								
28																								
29																								
30																								
31																								
32																								
33																								
34																								
35																								
36																								
37																								
38																								
39																								
40																								
41																								
42																								
43																								
44																								
45																								
46																								

Note 21 - The jet hole approach was curved to improve the hole coefficient.

Note 22 - The K500 compressor was used.

Note 23 - A water cooling spray was added above the combustion chamber

Note 24 - A smooth approach was incorporated in the jet hole.

TEST _____ FORM 707 A LYCOMING
Division - The Aviation Corporation

Date _____ Test No. _____

Engine Type _____ No. _____ Sheet No. 6

Compression Ratio _____

ENGINE LOG

FUEL - 73 OCTANE AVIATION GASOLINE

	RUN NUMBER																									
1	DATE		2-7-46																							
2	TIME		10:59	11:14	1:55	1:59	2:10	2:15	2:28	2:30		2:35	2:45	2:50	2:51	3:00	3:05	3:16	3:21		3:26	3:27	3:28	3:30	3:32	
3	R.P.M. X 2		1600			1610	1610	1825	1825			1825	1825	1825	2000	2000	2000	2000								
4	I.P.M.		800			805	805	912	912			912	912	912	1000	1000	1000	1000			875	800	730	600	500	
5	MAIN AIR PRESS.	P.S.I.	41			51.5	52.5	60	60			60	61.5	61	61.5	61.5	61.5	61.5								
6	COMB. CHAMB. TEMP.	°F	1800			1680	1805	1900	1940				2075	2030	2000	2000	1930	2000								
7	ROTAMETER	LB./HR.	17			17.5	17.7	19.6					23	21	18.9	18	18.5	21.5								
8	FUEL CONS.	GAL.				.5	.5		.5					.5												
9	FUEL TIME	MIN:SEC.					12:50		9:35					9:34.8			9:31.82									
10	GAS TEMP.	°F				66	64	61.7	60.8			59	57	56	56	55	55	55			60	60	55	48	40	
11	FUEL COMP. PRESS.	P.S.I.	95			116	120	120	120			125	125	130	110	120	120	118			130	140	165	148	145	
12																										
13	CYLINDER TEMP. INL. END	°F					90		90				90				95									
14	VALVE STEM INL. END	°F					1060		1100				1170				1030									
15	VALVE STEM JET END	°F					1030		1080				1140				1060									
16																										
17	TIME INTERVAL	HR:MIN		:15						:35									:46							
18	TOTAL TIME	HR:MIN	7:44.5	7:59.5						8:34.5									9:20.5							
19																										
20	NOTE NUMBER		25	26						27					28											
21																										
22																										
23																										
24																										
25																										
26																										
27																										
28																										
29																										
30																										
31																										
32																										
33																										
34																										
35																										
36																										
37																										
38																										
39																										
40																										
41																										
42																										
43																										
44																										
45																										

Note 25 - A ball check was installed in a line between the combustion chamber and a pressure gage to determine peak chamber pressures.

Note 26 - The unit was stopped to replace the valve plate gasket.

Note 27 - The flow meter was surging more than a normal amount. The surge chamber on the gasoline pump was removed and drained.

Note 28 - The unit was very critical on fuel adjustment to obtain a good flame and regular firing.

TEST ... Form 707 ... LYCOMING Division - The Aviation Corporation ... Date ... Test No. ... 27 Pages, Page 17 Report No. 909

Engine Type ... No. ... Sheet No. 6

Compression Ratio ...

ENGINE LOG

CONFIDENTIAL

FUEL - 73 OCTANE AVIATION GASOLINE

	RUN NUMBER																							
1	DATE		2-7-46					2-8-46																
2	TIME		3:33	3:35	3:37	3:40		2:38	2:40		3:07	3:10	3:20	3:30	3:37	3:41	3:46	3:53	3:55	4:10	4:11	4:16	4:20	
3	R.P.M. X2							2000			2000	2000	2000	2000	2000	2200	2200	2200	2400	2400	2400	2400		
4	I.P.M		405	300	250			1000			1000	1000	1000	1000	1000	1100	1100	1100	1200	1200	1200	1200		
5	RAM AIR PRESS.	P.S.I.	35	36	32.5							61	61	61.5	62	61	61	60.3	61	64.0	63	63		
6	COMB. CH'BR. TEMP.	°F										1810	1770	1790	1800	1800	1820	1810	2000	2040	2040	2070		
7	ROTOMETER	LB./HR.											21	21.5	22	22	17.5	17.5	20	20	20.5	18.5		
8	FUEL QUAN.	GAL.											.5					.6						
9	FUEL TIME	MIN:SEC.											9:24.99					9:58.1						
10	GAS TEMP.	°F										63	62	61	61	58	57.5	56.5	60	55				
11	PEAK COMB. PRESS.	P.S.I.	130	140	136							120	118	118	118	115	112	112	100	98	98	97		
12																								
13	CYLINDER TEMP. INL. END	°F											78	80	80		80	80		80				
14	VALVE STOP INL. END	°F											1000	980	990		950	940		1080				
15	VALVE STOP JET END	°F											1020	1020	1040		980	960		1060				
16																								
17	TIME INTERVAL	HR:MIN.				:14			:62													1:13		
18	TOTAL TIME	HR:MIN.	9:20.6			9:34.5					9:36.5											10:49.2		
19																								
20	NOTE NUMBER						29	30	31		32							33		34				
21																								
22																								
23																								
24																								
25																								
26																								
27																								
28																								
29			Note 29 - The read valve was found to require about 1/6 of the force previously required to remove the bow. An attempt to increase the bow damaged the read so number three valve was installed in the unit.																					
30																								
31																								
32			Note 30 - The jet plate hole was increased from .280 to .3125 diameter.																					
33																								
34			Note 31 - Engine blew out jet plate gasket in about one minute. The jet flame started to shorten but was restored by increasing fuel flow from 18 to 43 lb./hr. The ram air pressure dropped from 61 to 43 PSI. The peak combustion pressure increased from 120 to over 200 PSI. This confirms the need to further increase the jet area.																					
35																								
36																								
37																								
38																								
39			Note 32 - The jet plate gasket was replaced.																					
40																								
41			Note 33 - The ignition was shut off for one minute to allow engine to auto fire. No changes in pressures or temperatures were noted.																					
42																								
			Note 34 - The engine was very critical on fuel adjustment. Timing was irregular.																					

LYCOMING
Division of The Aviation Corporation

Date _____ Test No. _____

Engine Type _____ No. _____ Sheet No. 7

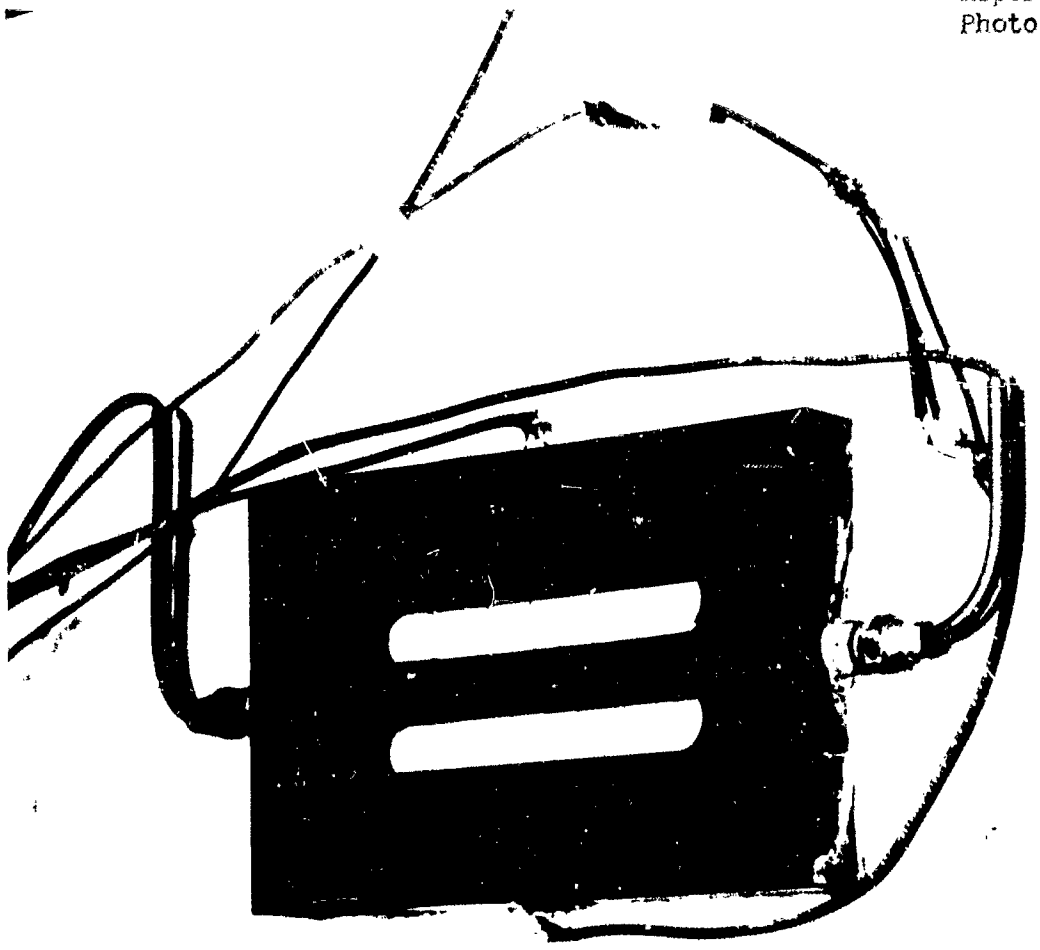
Compression Ratio _____

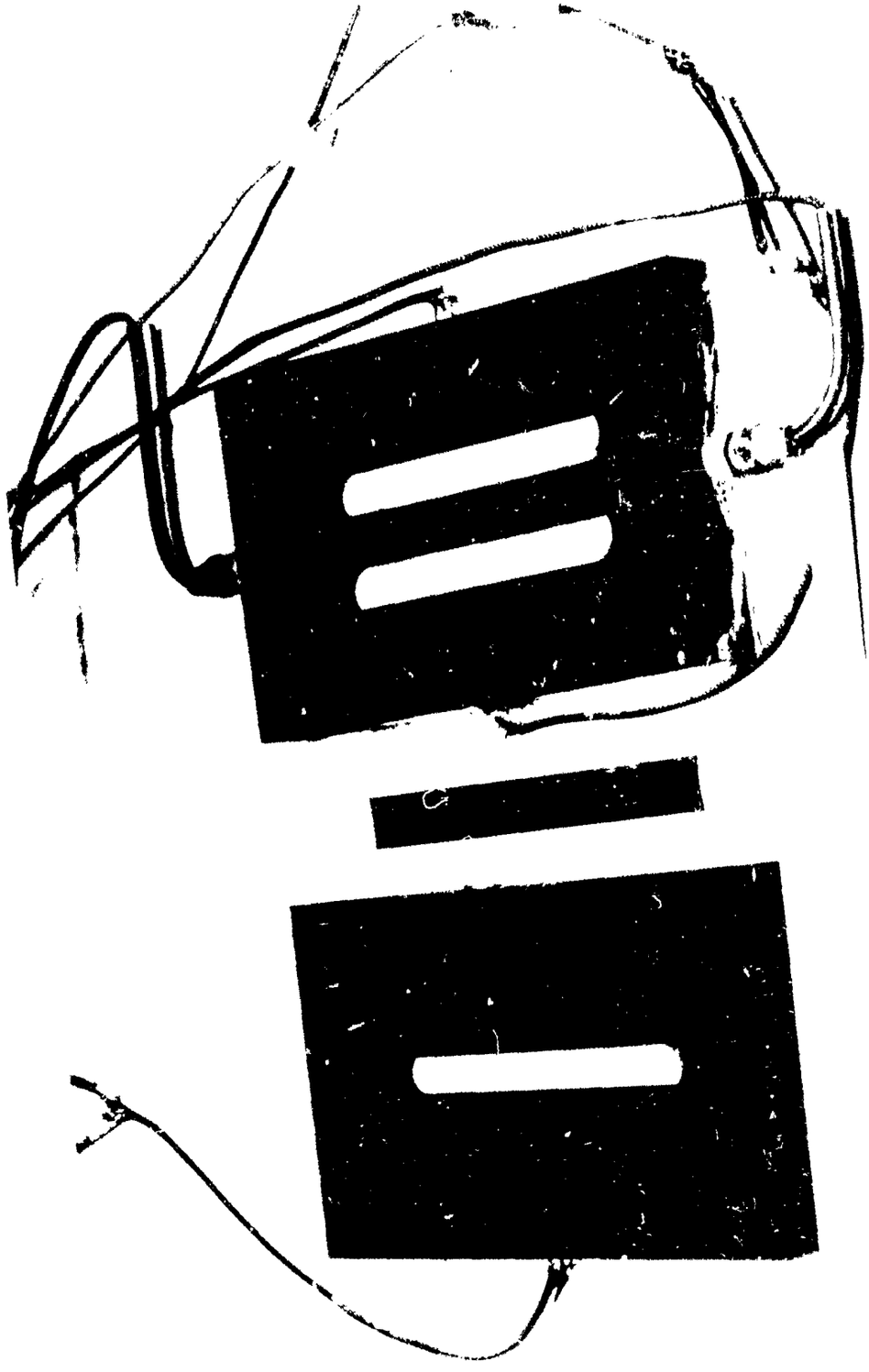
CONFIDENTIAL

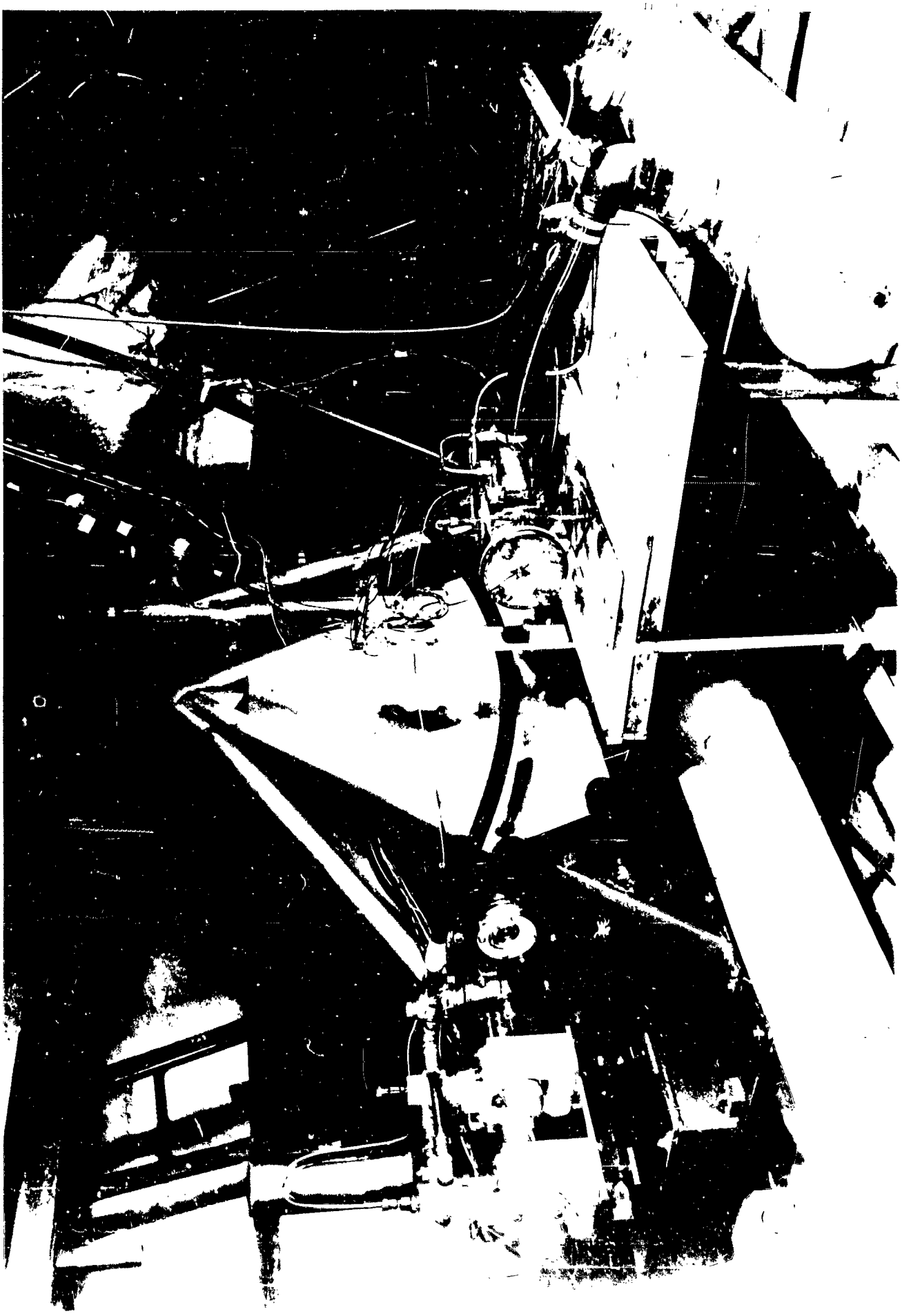
FUEL - 73 OCTANE AVIATION GASOLINE

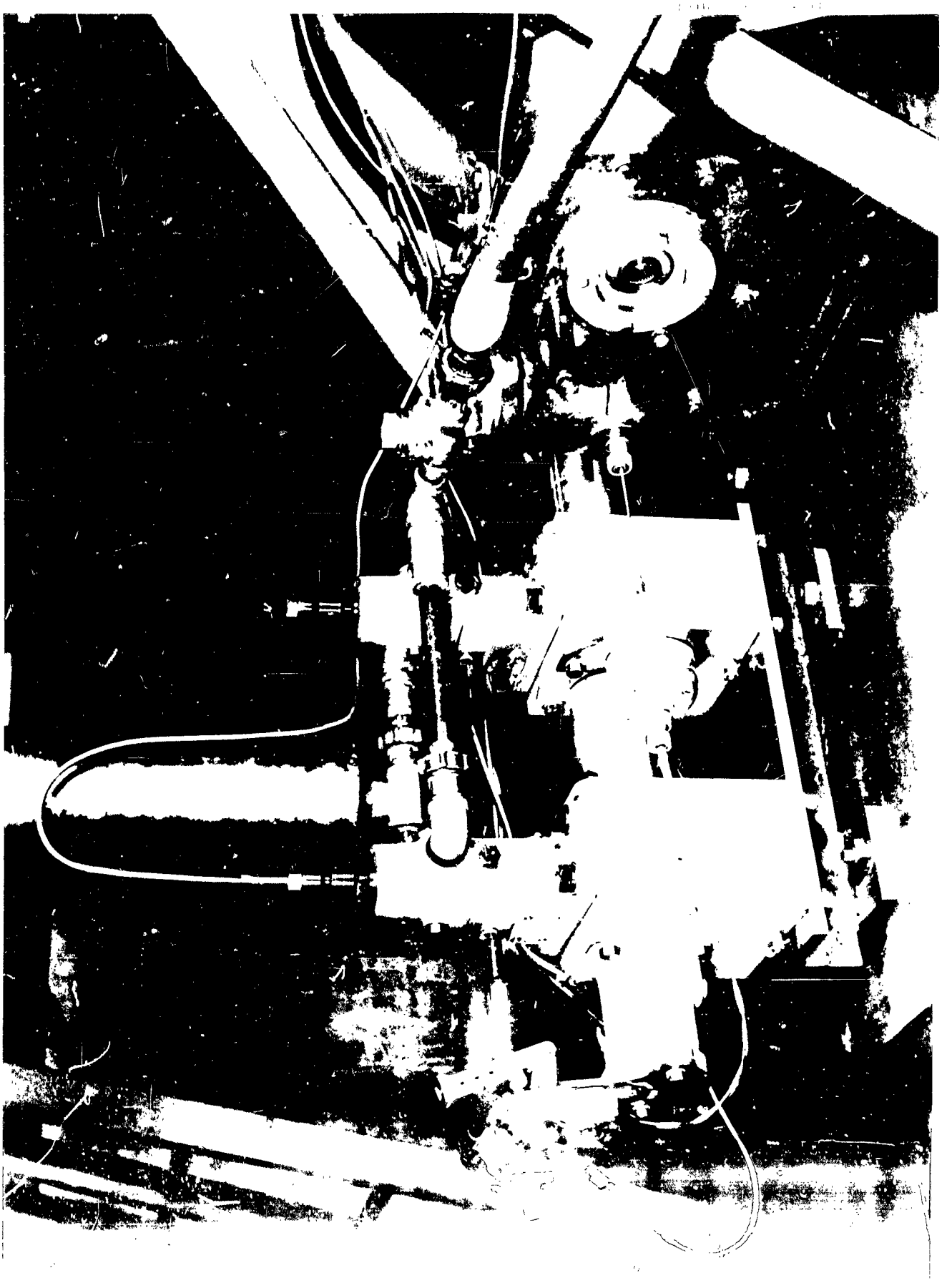
ENGINE LOG

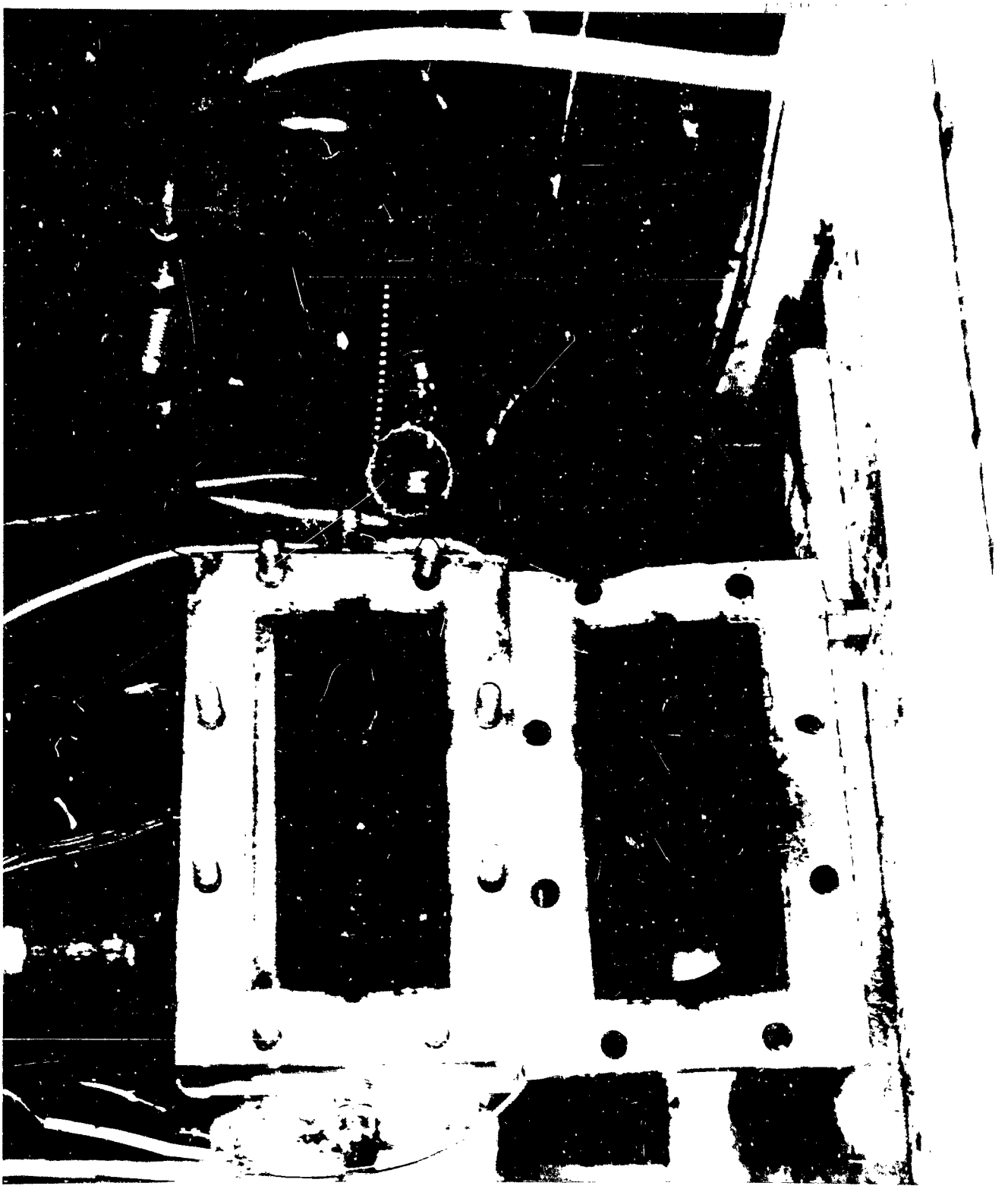
	RUN NUMBER						
1	DATE		2-9-46				
2	TIME		9:53	10:03	10:10	10:12	10:14.6
3	R.P.M. X 2		1200	1200	1200	1610	
4	I.P.M.			600	600	805	
5	RAM AIR PRESS.	P.S.I.		50	50	65	
6	COMB. CH'B'R. TEMP.	°F		1510	1600	1840	
7	ROTOMETER	LB./HR.		41	37	48	
8	FUEL QUAN.	GAL.		.5			
9	FUEL TIME	MIN: SEC.		5:14.97			
10	GAS TEMP.	°F		682	59		
11	PEAK COMB. PRESS.	P.S.I.		210	210	205	
12							
13	CYLINDER TEMP. INL.END	°F	-		90		
14	VALVE STOP INL. END	°F			850		
15	VALVE STOP JET END	°F			900		
16							
17	TIME INTERVAL	HR: MIN				:21.6	
18	TOTAL TIME	HR. MIN.	9:40.6			10:11	
19							
20	NOTE NUMBER		35			36	
21							
22							
23							
24							
25							
26							
27	Note 35 - Three 3/16 diameter jet holes were added. Mal-firing occurred at 1000 RPM so operation						
28	was reduced to 600 RPM.						
29							
30	Note 36 - The engine was stopped when mal-firing occurred due to valve failure.						
31							
32							
33							
34							
35							











~~CONFIDENTIAL~~


1
2
3
4
5
6

~~CONFIDENTIAL~~